Report on the 2nd ESF-MedCLIVAR workshop
«Connections between Mediterranean and global climate variability»
La Londe les Maures, Toulon, France, Oct. 8-10, 2007

The second ESF-MedCLIVAR workshop was held in La Londe les Maures, France, from 8 to 10 October 2007. The workshop was entitled «Connections between Mediterranean and global climate variability». The Workshop was co-sponsored by the IPSL/CNRS. In total, 35 oral presentations, together with 12 posters, were given during the workshop. 56 senior and young scientists and Ph.D. students have taken part in the workshop. They are respectively from 12 different countries: France (19), Spain (10), Italy (6), Germany (4), Israel (4), Portugal (3), U.K. (3), Egypt (2), Switzerland (2), Greece (1), Lybia (1), and Tunisia (1).

The workshop was divided into six scientific sessions: 1) Reconstruction of past climate teleconnection; 2) Teleconnection with mid-latitude systems; 3) Teleconnection to tropical systems; 4) Teleconnections and the Mediterranean circulation; 5) Teleconnection in modelling; 6) Impacts of climate change. All aspects of the teleconnection between the Mediterranean and global climate were thus covered by the workshop.

The main conclusion of the workshop is that the Mediterranean region is a climate transition area, tightly related to the global climate variability, and intense scale-interaction processes take place in this area. The Mediterranean region is not only under the influence of tropical phenomena, such as ENSO and tropical monsoons, but also under strong control of mid and high latitude meteorological systems.

Although a few national projects of the Mediterranean countries and several ongoing international research projects have their focus on the Mediterranean climate and environment change, participants recognize that further actions should be encouraged to study the physical mechanisms controlling the climate change and variability of the Mediterranean region. The workshop recommends in particular the following actions in the future. 1) Increase the data-obtention capacity for the region, including collection of operational meteorological and hydrological networks, deployment of targeted field campains and exploration on historical climate archives. 2) A complete methodology with advanced diagnostics should be further developed and used in order to study and quantify relevant teleconnection mechanisms. 3) Develop and utilize high-resolution and coupled numerical simulation platforms.

Laurent Li
On behalf of the Organizing Committee
Paris, Feb. 12, 2008

ESF-MedCLIVAR 2nd workshop

Connections between Mediterranean and global climate variability

La Londe les Maures, Toulon, France, Oct. 8-10, 2007

Organizing Committee:

Laurent Li, chair (LMD/IPSL/CNRS Paris, FRANCE)
Pinhas Alpert (Tel-Aviv Uni., ISRAEL)
Philippe Fraunie (Uni. Toulon, FRANCE)
Ricardo Garcia (Complutense Uni. Madrid, SPAIN)
Piero Lionello (Uni. Lecce, ITALY)
Heiko Paeth (Uni. Würzburg Am Hubland, GERMANY)
Ricardo Trigo (Uni. Lisboa, PORTUGAL)
Mikis Tsimplis (NOCS, Southampton, UK)
Roberta Boscolo (IIM-CSIC, Vigo, SPAIN)

Programme

Monday Oct. 8, 2007

9:00-9:20	Li, Fraunie, Lionello	Introduction and welcome
	SESSION 1	**Reconstruction of past climate teleconnection (Chair: Piero Lionello)**
09:20-09:40	Marcel Kuettel	An improved North Atlantic, European and Mediterranean Sea level pressure reconstruction 1750-1850
09:40-10:20	Elena Xoplaki	Winter Mediterranean temperature and precipitation back to 1750: the large-scale sea level pressure and ENSO influences
10:20-10:40	Vicent Altava	Monthly rainfall behaviour in central and western Mediterranean basin, from 1850 to 2004
10:40-11:00	Alexandra Gogou (cancelled)	Evidence of paleoclimatic changes in the Aegean Sea (NE Mediterranean) during the last 20 Kyrs: teleconnections to global climatic variability
11:00-11:40	**Coffee break**	
11:40-12:00	Pascal Yiou	Climate proxies from French historic archives (the OPHELIE ANR project)
12:00-12:20	Younis al-Fenadi	Temperature variability and trends in North Libya from 1961 to 1990
12:20-14:20	**Lunch**	
	SESSION 2	**Teleconnection with mid-latitude systems (Chair: Antje Voelker, Ricardo Trigo)**
14:20-15:00	Ricardo Trigo	Weather-driven natural hazards in western Mediterranean; the role of storm tracks, blocking episodes and NAO
15:00-15:20	Jose Carlos Gonzalez-Hidalgo	Spatial overlapping areas of several teleconnection indices on Spain's Mediterranean facade according to Spring rainfall
15:20-15:40	Annick Douguédroit	Teleconnections between significant decreasing precipitation and Atlantico-European circulation in the Mediterranean (1951-2000)
15:40-16:00	Tamara Salameh	Statistical Downscaling of Near-Surface Wind over Complex Terrain in Southern France
16:00-16:40	**Coffee break**	
16:40-17:20	Uwe Ulbrich	Relation of variability patterns and mediterranean cyclones
17:20-18:00	Pinhas Alpert	Teleconnection and the horizontal scale ?

Tuesday Oct. 9, 2007

09:00-09:40	Jucundus Jacobeit	Links of the Mediterranean oscillation to mid-latitude and tropical climate dynamics
09:40-10:00	Emily Black	The relationship between Atlantic and European circulation patterns and Middle East rainfall
10:00-10:20	Fabio d'Andrea	Hot European Summers: the propagation of Mediterranean drought
10:20-10:40	Marco Gaetani	Jet stream and seasonal anomalies in the Mediterranean
10:40-11:00	Blanca Ayarzaguena	Impact of interannual variability of stratospheric final warmings on the anomalous spring rainfall regime in the Mediterranean region
11:00-11:20	**Coffee break**	
	SESSION 3	**Teleconnection to tropical systems (Chair: Pinhas Alpert)**
11:20-12:00	Philippe Drobinski	Presentation and discussion on HyMex initiative (Mediterranean Hydrological cycle experiment)
12:00-12:30	Gidon Eshel (cancelled)	Montane diabatic Heating: an Alternative Subsidence Promoting Mechanism?
12:30-13:00	Ileana Blade	The dependence of the structure of the NAM (Northern Annular Mode) on the polarity of ENSO: impact in the Mediterranean sector.
13:00-14:40	**Lunch**	
14:40-15:20	Hadas Saaroni	The circulations and mechanismes governing the Summer temperature variations in the Eastern Mediterranean
15:20-15:40	Baruch Ziv	Regional and global scale patterns associated with rainfall anomalies in Israel
15:40-16:00	Joaquim Pinto	The role of ex-hurricanes on extreme precipitation events over the Western Mediterranean: an update based on ERA40 data
16:00-16:40	**Coffee break**	
	SESSION 4	**Teleconnections and the Mediterranean circulation (Chair: Alexandre Theocharis)**
16:40-17:20	Mikis Tsimplis	Teleconnections of the Mediterranean sea level
17:20-17:40	Clothilde Langlais	Interannual variability of exchanges in the Gulf of Lions: shelf dense water formation and cascading
17:40-18:00	Ali Harzallah	A nested ocean model for the Sicily strait with zooming on Tunisia coastal areas
18:00-18:20	Marine Herrmann	Impact of atmospheric forcing and ocean model resolutions on open-ocean convection: case study of winter 1986-87

Wednesday Oct. 10, 2007

09:00-09:40	Simon Josey	Relationship between Mediterranean Sea air-sea exchanges and large scale patterns of atmospheric variability
09:40-10:20	Vicenzo Artalez	Analysis of The Mediterranean Overflow in Climate Models. The role of the overflow account in the thermohaline circulation and in particular in the Mediterranean Sea
10:20-10:40	Antje Voelker	Linkages between North Atlantic surface water circulation patterns and Mediterranean Outflow variability on the western Iberian margin: Examples from Marine Isotope Stages 3 and 12 to 10
10:40-11:20	**Coffee break**	
	SESSION 5	**Teleconnection in modelling (Chair: Samuel Somot)**
11:20-12:00	Heiko Paeth	Regional dynamical downscaling of Mediterranean climate - climate change perspectives.
12:00-12:20	Laurent Li	Scale interaction in a regional Mediterranean climate simulation
12:20-12:40	Simon Krichak	Assessing mechanisms of future climate trends over the E. Mediterranean region based on results of multiple RCM simulations
12:40-14:20	**Lunch**	
14:20-15:00	Silvio Gualdi (cancelled)	Climate variability in the Euro-Mediterranean region and its connections with the large scale circulation as simulated in CGCM experiments
15:00-15:20	Sandro Calmanti	A Regional System for climate change assessment in the Mediterranean region: preliminary results
	SESSION 6	**Impacts of climate change (Chair: Roberta Boscolo)**
15:20-15:40	Mahmoud Ahmed	Climate change effects on coastal resources and marine environment of Egypt
15:40-16:00	Noha Donia	Effect of climate change on water resources in Egypt
16:00-16:30	**Coffee break**	
16:30-18:00	**DISCUSSION and CONCLUSION (Piero Lionello)**	
	POSTERS:	
1	Alexandre Ramos	Synoptic patterns leading to extreme temperatures over Portugal
2	Raquel Garcia Gonzalez (cancelled)	Drought effects on net ecosystem exchange, water fluxes and ecosystem respiration in Mediterranean forests: controls and feedbacks

3	David Barriopedro	Climate impacts over the Mediterranean basin associated with blocking occurrence
4	Tzvi Harpaz	Atmospheric conditions in the eastern Mediterranean during extreme summer events - preliminary results
5	Maria-Carmen Llasat	Trends and anomalies of the regional precipitation in Spain along the 20th century
6	Maria-Barbara Galati	Influence of teleconnection patterns on the Mediterranean marine wave height distribution
7	Javier Garcia-Serrano	Summer-Fall tropical precipitation related to Mediterranean SST anomalies
8	Emilia Sanchez-Gomez	Weather regimes and local climate on the Mediterranean basin
9	Masa Kageyama	Mediterranean climate changes in glacial times and their links with global change: a model study
10	Virginie Guemas	Circulation regimes and sea surface temperatures in the North Atlantic
11	Albin Ullmann	Atmospheric conditions associated with sea surges in the Gulf of Lions: contemporary and future variability
12	Sara Queralt	Atlantic influence on western mediterranean mesoscale convective systems

AN IMPROVED NORTH ATLANTIC, EUROPEAN AND MEDITERRANEAN SEA LEVEL PRESSURE RECONSTRUCTION 1750-1850

Marcel Küttel[1]; Elena Xoplaki[1], David Gallego[2], Ricardo García-Herrera[3], Jürg Luterbacher[1], Rob Allan[4] and Tara Ansell[4]

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4 Hadley Centre, Met Office, Exeter, United Kingdom.

Local to regional climate anomalies at different time scales (daily-seasonal) are to a large extent determined by the state of the atmospheric circulation. Thus, advective and convective processes exerted by the atmospheric circulation are a crucial factor controlling local to regional changes of precipitation and temperature. Knowledge of past large scale Sea Level Pressure (SLP) is thus essential to address changes in observed past climate variability across Europe and the Mediterranean. However, a widespread distribution of instrumental station pressure measurements for the construction of gridded datasets of past SLP is only available since the mid-nineteenth century (e.g. Allan and Ansell, 2006, J. Climate). Prior to this period, reconstructions for the eastern North Atlantic-European area rely on a multiproxy predictor dataset including a few very long instrumental records, documentary proxy evidence and a couple of natural proxies (e.g. Luterbacher et al. 2002, Clim. Dynam.). For dynamical analyses, these climate reconstructions however contain deficiencies. First, they include common predictors (temperature and precipitation) in the statistical reconstruction procedure, thus causing circularity effects when relating circulation to climate variability. Secondly, they lack early information from marine regions that could capture the variability of the major centres of action (Azores High and the Icelandic Low).
A way to overcome these issues are historical climate information preserved within ship logbooks. The CLIWOC project (e.g. García-Herrera et al. 2005, Climatic Change) digitised and translated information on wind direction and wind strength from ship logbooks, producing a record of past wind conditions over the world's oceans for the period 1750-1850. Recent publications (Gallego et al. 2005, Climate of the Past; Jones and Salmon 2005, Climatic Change) have shown that this data can skilfully reconstruct past SLP over the eastern North Atlantic back to the mid-eighteenth century. Our study is a first attempt to combine information from terrestrial, instrumental station SLP series and marine wind information contained within the CLIWOC database to statistically reconstruct seasonally resolved gridded SLP back to 1750. Prior to around 1800, the majority of predictor information stems from CLIWOC data, while afterwards the number of instrumental records steadily increases. For calibration, the newly available gridded monthly resolved SLP dataset from 1850 to 2002 (Allan and Ansell 2006) was used. Preliminary results indicate that a significant increase in reconstruction skill is achieved over the 1750-1850 period for the eastern North Atlantic and the Mediterranean area (i.e. the NAO variability, the strength of the westerly component as well as the location of the Azores High and Icelandic Low can be more accurately captured) if CLIWOC data is combined with terrestrial station pressure series. In a companion paper (Xoplaki et al., in prep. And invited contribution to this workshop) the new blended 1750-1850 gridded SLP dataset together with the improved gridded SLP record by Allan and Ansell (2006) from 1851-2004 will be related to Mediterranean winter temperature and precipitation to study the main circulation modes responsible for climate variability over the last 250 years.

MONTHLY RAINFALL BEHAVIOUR IN CENTRAL AND WESTERN MEDITERRANEAN BASIN, FROM 1850 TO 2004.

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Changes in statistical distribution of rainfall amounts have been studied in four Mediterranean regions (figure 1): France and Spanish Mediterranean coasts, Sardinia Island and the Calabrian region in Italy. The largest precipitation series (with more than 70 years) in these zones have been collected and studied at yearly and monthly time scales by means of different parametric and non-parametric techniques.

Non-parametric procedure has been focused on continuous time series changes, while possible changes at the end of the 20th century have been studied developing a parametric method. Among the results obtained, some annual and monthly significant trends have been found as well as some changes at the end of the last century. On one hand, results show that some expected pluviometric changes in the Central Mediterranean Basin seem to be already observable mainly in winter period. In central Mediterranean areas rainfall values are clearly going down in the analysed stations. Those changes take an especial relevance thus more than 60% of annual precipitation amounts in Central Mediterranean occur in winter months. On the other hand, the decade 1985-1994 shows some of the driest values in all regions. Despite that, no continuous significant changes have been found in the analysed Western Mediterranean regions.

Weather patterns and circulation indices during the analysed period have been used for providing possible causes of such rainfall observed changes.

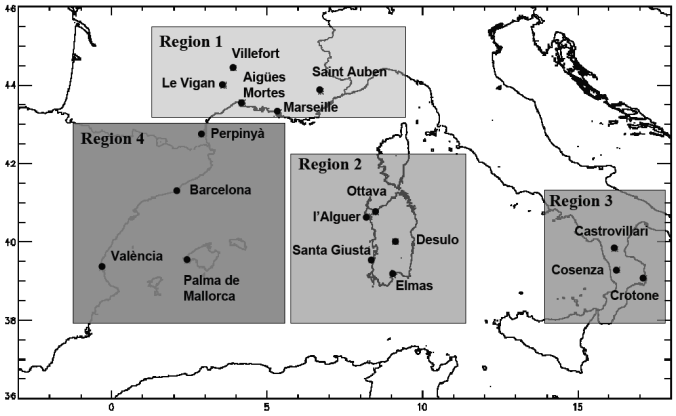

Figure 1. Analysed regions in Central and Western Mediterranean

Temperature variability and trends in North Libya from 1961 to 1990

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Very few published studies exist on climate variability over Libya, and this study is a contribution toward that goal. The analysis attempts to investigate the variability and trend in monthly surface temperature observed over North Libya. The data used in this study consist of the collection of eight northern stations from January 1961 through to December 1990. The temperature anomalies, obtained as departures from the seasonal cycle, show a great deal of variability across both the months and the stations. Most variability occurs during the autumn and winter months. Summer months exhibit the least variability. Temperature anomalies exhibit variable skewness during autumn months. All stations show long-term temperature trends in annual mean temperature with a decrease until the mid-seventies and an increase thereafter. A North Libya temperature index (NLTI) was constructed by spatially–averaging the monthly values at the eight stations. The analysis of this index shows that most winter and autumn months exhibit the largest variability. During spring, only May has the biggest variability with the least variability obtained in summer. The annual temperature averages obtained from NLTI have been investigated for trend using a quadratic fit and shows also a decrease until 1975 then an increase thereafter. It is found in particular that autumn and also winter seasons contribute the most to the long-term annual trend. Teleconnections of NLTI with (NCEP/NCAR) sea level pressure and 2m surface air temperature for individual seasons have also been investigated. High correlations are obtained with sea level pressure during winter over north Libya. A dipolar correlation pattern is obtained over the northwestern part of the North Atlantic. The pattern is similar to negative NAO except that it is slightly shifted northward. A similar result is obtained with 2m surface air temperature, showing that the NAO has a major contribution to the observed trend of surface temperature over Northern Libya in wintertime

SPATIAL OVERLAPPING AREAS OF SEVERAL TELECONNECTION INDICES ON SPAIN'S MEDITERRANEAN FAÇADE ACCORDING TO SPRING RAINFALL.

J. Carlos González-Hidalgo[1], Joan A. Lopez-Bustins[2], Javier Martin-Vide [2], Michelle Brunetti[3], Teresa Nanni [3], Petr Stepanek [4], Martín de Luis[1].

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We have analysed the spatial variability of spring precipitation (March-April-May) with the use of four teleconnection indices on Spain´s Mediterranean façade. The rainfall database consists of monthly, homogeneous and complete series from over 1100 meteorological stations (for the 1951-2000 period), throughout an area covering approximately 1/3 of the Iberian Peninsula (IP). The indices series were provided by several institutions: MCI (ISAC-CNR, Bologna), MOI and NAOI (CRU, Norwich), and WeMOI (Group of Climatology, Barcelona).

The most widespread correlated index throughout the study area in March is MOI, except for the Pyrenees and the NW most inland Ebro Catchment, where NAOI and WeMOI - MCI predominate. The spatial distribution of the correlations is greatly different between April and May. In April NAOI predominates in northern area and WeMOI in southern ones, whereas no index predominates in May and no clear pattern exists. The four teleconnection indices negatively correlate with precipitation over the Eastern Iberian façade, except for those positive correlations found between the WeMOI and rainfall in the north-western area.

The high spatial and temporal variability of the spatial distribution areas of the most correlated indices suggests that spring precipitation is featured by such a complex genetic processes. Furthermore, monthly analysis enables some spatial shifts of these regions to be recognised. Lastly, it must be highlighted that the NAOI is usually less correlated than other teleconnection indices, except for April.

TELECONNECTIONS BETWEEN SIGNIFICANT DECREASING PRECIPITATION AND ATLANTICO-EUROPEAN CIRCULATION IN THE MEDITERRANEAN (1951-2000)

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The aim of the paper lies in the identification of teleconnections between significant linear trends of several rainfall indices (totals, number of rainy days and of precipitation daily means at monthly, seasonal and annual timescales) in the Mediterranean from 1951 to 2000 and atmospheric circulation dynamics at the Atlantico-European scale in which such significant trends originated.

Eight precipitation sub-areas have been determined by applying RPCAs (Rotated Principal Component Analyses) to the different indices with stations as variables and indices as observations. Then CCAs (Canonical Correlation Analysis) have been used to establish relations between rainfall and circulation. Trends are calculated by using the scores of the eigenvectors retained in each RPCA or CCA and tested with the non-parametric Kendall test on ranks at the 0,05 level. On the whole, lack of trend and non-significant trends are greatly prevailing at the monthly and consequently the seasonal and annual timescales in the Mediterranean Basin from 1950 to 2000. Significant decreasing trends have been determined in some regions during particular months and season (October in Mediterranean Spain, March in the Atlantic region, January and winter in Greece and winter in the Near East.

CCAs have been applied only to the cases of significant decrease mentioned before. Precipitation are partially explained by two to four low-frequency circulation patterns with one or two CCPs (Canonical Correlation patterns) having scores with significant trends. Regimes associated to each pattern have been featured studying the years of the maximum and minimum rainfall and geopotential height scores for each CCP, which correspond according to the very high correlation between both variables. The maximum and minimum regime types have been divided between two subsets, corresponding one to the zonal circulation, the other to the meridian circulation.

STATISTICAL DOWNSCALING OF NEAR SURFACE WIND FIELD OVER COMPLEX TERRAIN IN SOUTHERN FRANCE.

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The Mediterranean region features a near closed sea surrounded by very urbanized littorals and mountains from which numerous rivers originate. This results in a lot of interactions and feedbacks between oceanic-atmospheric-hydrological processes which frequently cause extreme events (heavy precipitation and flash-flooding, strong winds and large swell, droughts) that produce heavy damages and human losses. The ability to predict such dramatic events remains weak because of the contribution of very fine-scale processes and their non-linear interactions with the larger scale processes.

In this context, trends in near-surface wind speeds are acknowledged as having particular importance for climate change impacts on society (e.g., the insurance industry, coastal erosion, forest and infrastructure damage, storm surges, and air-sea exchange). They also have relevance for applications such as pollutant diffusion evaluation, wind energy resource estimation and construction issues. Surface wind speeds however exhibit variability at much smaller spatial scales than that resolved by general circulation models (GCM) and hence there is a need to develop tools for downscaling GCM projections to generate finer scale projections of near-surface wind climatologies.

In the present study, the region of interest focuses on the northwestern Mediterranean basin in southern France which is a region with complex coast shapes and high orography (the Alps, the Massif Central and the Pyrénées culminating at 4807 m, 1885 m and 3298 m, respectively. The major fine-scale wind regimes are thus largely due to this complex coastal environment and are dominated by: (1) the Mistral and its companion wind, the Tramontane which are frequent (5 to 15 days per month all year long) severe northerly/northwesterly winds that develop along the Rhône and Aude valleys and are preconditioned by cyclogenesis over the Gulf of Genoa and the passage of a trough through France (these wind storms can cause severe damage to farm plantations, hazardous conditions for aeronautics and ship, increase forest fire risks in the region and are one of the primary causes of storms over the Mediterranean; e.g. Drobinski et al.,2005); (2) the breezes during summer (the sea/land-breeze impacts on air quality in the region; see Drobinski et al., 2007 for a review); and (3) the onshore winds during fall season (causing frequent intense precipitations and flash-flooding in the Cévenes region; e.g. Ducrocq et al., 2002).

If during summer, the Mediterranean climate system is relatively isolated, during other periods teleconnections are more important (e.g. Dünkeloh and Jacobeit, 2003). The aim of the present study is thus to identify during winter, the possible relation between the dominant fine-scale patterns of near-surface winds with large-scale weather regimes characterizing the typical large-scale atmospheric circulation in the northern and meridional European area. Further more in our study, we compare the results of the statistical downscaling of the wind to those of a dynamical downscaling, simulated using a regional circulation model.

LINKS OF THE MEDITERRANEAN OSCILLATION TO MID-LATITUDE AND TROPICAL CLIMATE DYNAMICS

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The Mediterranean Oscillation (MO) as a regional dynamic system with prevailingly opposite pressure conditions between the western to central and the eastern Mediterranean area may be represented by various station pressure difference indices (e.g. between Algiers and Cairo, Gibraltar and Lod, Marseille and Jerusalem) or by particular large-scale circulation patterns which include this pressure seesaw in the Mediterranean region (Dünkeloh and Jacobeit 2003). These MO patterns correlate significantly with the Northern Hemisphere modes of the AO (Arctic Oscillation) and the NAO (North Atlantic Oscillation). However, this connection shows a seasonal cycle with relationships being best developed during winter, fading away towards summer, and recovering during next winter. On the other hand, during late summer and autumn there is a strong influence of ENSO (El-Nino-Southern-Oscillation) variability on the MO revealed by similar patterns of opposite sign in correlation maps for corresponding indices and upper-level geopotential height anomalies (Seubert and Jacobeit 2007). Thus, the Mediterranean Oscillation changes its teleconnectivity according to the seasonal cycle and reflects different large-scale influences on regional climate during different seasons.

References:

Dünkeloh, A. and J. Jacobeit (2003): Circulation Dynamics of Mediterranean Precipitation Variability 1948-98. Int. J. Climatol. 23: 1843-1866.

Seubert, S. and J. Jacobeit (2007): Tropical Influences on Mediterranean Precipitation Variability. Geophysical Research Abstracts 9.

THE RELATIONSHIP BETWEEN ATLANTIC AND EUROPEAN CIRCULATION PATTERNS AND MIDDLE EAST RAINFALL

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Understanding the relationship between large-scale atmospheric circulation over Europe and the Atlantic and rainfall in the Middle East is crucial to our understanding of Middle East rainfall variability on daily to decadal time scales. Circulation patterns over Europe and the North East Atlantic can be described using an objective classification of synoptic regimes based on the well-established Grosswetterlagen series (herein referred to as objective-GWLs) (see James(2007) Theoretical and Applied Climatology DOI: 10.1007/s00704-006-0239-3). The daily time series of objective-GWLs was compared with rain data for nine stations in Jordan. It was found that the probability of rainfall on a given day was significantly greater for some objective-GWL regimes than others. On interannual to deacadal time scales, modes of variability in the Atlantic and Europe, such as the North Atlantic Oscillation (NAO) are known to affect Middle East rainfall (see for example Krichak and Alpert (2005) Theoretical and Applied Climatology DOI: 10.1007/s00704-004-0119-7). Comparison between the distribution of objective-GWL regimes in NAO positive and negative seasons shows that some of the objective-GWL regimes favoured during when the NAO is positive are associated with a high probability of rain in Jordan. The final part of this study investigates the mechanisms by which particular objective-GWL regimes favoured when the NAO is in its positive phase, give rise to high rainfall in Jordan. This provides insights both into how the teleconnection between the NAO and Middle Eastern rainfall works, and into how interannual and decadal variability in the NAO affects daily rainfall in Jordan.

JETSTREAM AND SEASONAL ANOMALIES IN THE MEDITERRANEAN.

Marco Gaetani; Marina Baldi and Giovanni A. Dalu

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In the context of regional climate change, the Mediterranean climate variability constitutes an issue of particular concern, because in the last decades the number of cyclones has declined, the total rainfall reduced, while the temperature has increased, which can finally lead to a subregional desertification process. We analyze the jetstream position in the region including North Atlantic, Europe and North Africa, in relation to the Mediterranean temperature anomalies in the warm season, and to the rainfall anomalies in the cold season.
Comparing the rainfall in two sub-basins, we find that in fall (winter) the West (East) Mediterranean basin is wetter than the Eastern (Western) basin, therefore we analyze the seasonal climatology in order to explain the differences between the two sub-basins. In the region including North Atlantic, Europe and North Africa, the westerly jetstream has two main branches: the Atlantic jet and the North African jet. In fall, the jets are weak, with the North African jet displaced eastward: the flow is rather zonal and the rainfall is abundant the Western Mediterranean, strengthened by the orography. In winter, the jets are strong, with the Atlantic jet tilted towards the Scandinavian peninsula and the North African jet spanning the whole North Africa: the flow is deflected from northern Europe to the Balkan peninsula and the rainfall is abundant in the Eastern basin. The Atlantic jet acts as a waveguide for the Atlantic storms, carrying the rainfall to the Euro-Mediterranean region, with the North African jet modulating between the two sub-basins.
In the Mediterranean basin, July and August are the hottest months, with the highest rate of occurrence of heat waves, therefore we assume that these are the significant months for the temperature anomalies. In summer the two jets are displaced further north and have a less north easterly tilt than in winter. When the meridional distance between the Scandinavian and the North African jet is small, the subsiding branch of the transverse circulation of the two jets induces an adiabatic tropospheric warming. This often adds up to a more localised warming related to the northwards displacement by the West Africa monsoon of the Libyan anticyclone into the West basin. When the meridional distance between the Scandinavian and the North African jet is large, the summer is relatively cool, with the Libyan anticyclone positioned back over the Libyan desert.

IMPACT OF INTERANNUAL VARIABILITY OF STRATOSPHERIC FINAL WARMINGS ON THE ANOMALOUS SPRING RAINFALL REGIME IN THE MEDITERRANEAN REGION

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Stratospheric Final Warming (SFW) is one of the most important processes in the springtime stratosphere of both hemispheres, due to the change from the wintertime to the typical summertime conditions in the stratospheric circulation. Certain studies have shown that the interannual variability in the timing of the SFWs is large and that it involves consequent variations in the polar ozone content, in the stratospheric circulation and in the way how the polar vortex breaks up. Some other works have linked the interdecadal changes in the date of the spring onset in the troposphere with a possible variation in the stratospheric circulation at the end of winter.

In this work, in contrast to the above studies, we have focused on the impact of the different timing of the northern hemisphere SFWs on the anomalous regime of rainfall in spring months over Europe and, especially, in the Mediterranean region.

In order to do that, we have selected two groups of years: those years when the northern polar vortex has broken up very early (in March) and those ones when it has occurred very late (in May). Then, using composite techniques we have analysed whether any difference in the precipitation pattern of Europe and in the tropospheric conditions exists in April. The data used are from ERA40 Reanalysis and Legates-Wilmott precipitation database, and the period studied is 1958-1999.

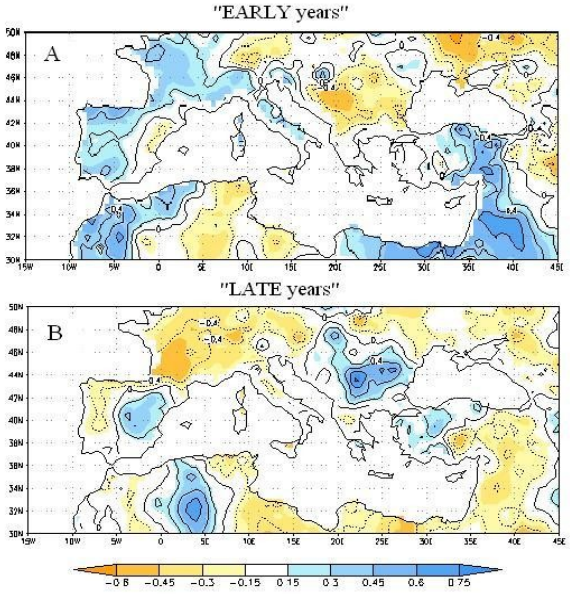

Fig.1. A: composite of monthly standardized precipitation anomalies in april for early sfw years. B: as in a but for late years. Contour interval: 0.2.

Among other results, concerning the Mediterranean area, we have found that the monthly precipitation in April of the "early years" is more than normal in the West and the East of Mediterranean basin (apart from Spanish Levante) and less than normal in the Balkans. The opposite occurs in the "late years" (Fig.1). However, the difference in the precipitation pattern is only statistically significant (at 95%) when, in addition, the stratospheric polar vortex is extremely anomalous during April, being the South of France and the Northeast of Italy the significant zones.

Moreover, when analysing the transient eddy energy at 500 hPa in April, a significant discrepancy over certain North Atlantic regions has been found between early and late SFW years, in such a way that early cases seem to be related to a southward shift of the storm tracks crossing Europe. This could explain the anomalous rainfall pattern shown

in Fig. 1, and provides a dynamical link between precipitation and atmospheric variability in the North Atlantic area.

In short, the results obtained in this study indicate that the variations in the persistence of the stratospheric vortex in springtime seem to have some impact on the rainfall pattern of the Mediterranean region in April.

THE DEPENDENCE OF THE STRUCTURE OF THE NAM (NORTHERN ANNULAR MODE) ON THE POLARITY OF ENSO: IMPACT IN THE MEDITERRANEAN SECTOR.

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We examine the dependence of the spatial structure of the Northern Annular Mode (NAM) on the polarity of ENSO, using both observations and a very large (150) ensemble of GCM simulations of the 1997/98 El Niño and 1998/99 La Niña events. The most important differences in the simulated NAM between warm and cold ENSO winters are found in the upper troposphere, where the NAM signature is enhanced during El Niño winters, particularly in the subtropics and over northern Africa. The NAM-related perturbations in temperature are also stronger during El Niño winters, particularly over the Mediterranean region. These changes are consistent with a large and widespread increase in subseasonal variance of upper-level heights over the Atlantic sector during warm ENSO events (in contrast the impact of ENSO on the Pacific sector is much weaker).

The more pronounced subtropical centre of action of the NAM during warm ENSO winters is consistent with ENSO-induced changes in the tropical upper level winds in the eastern Pacific, namely a weaker westerly duct during El Niño winters. This effect results in increased cross-equatorial propagation of midlatitude Rossby waves during La Niña winters and may also inhibit the propagation of wave activity from the Pacific into the Atlantic.

A detailed comparison with observations and other model simulations will be presented, as well as implications for the Mediterranean region.

THE CIRCULATIONS MODULATE THE SUMMER REGIME IN THE EASTERN MEDITERRANEAN

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In the summer season the eastern Mediterranean is subjected to two primary factors: mid–upper-level subsidence and lower level cool advection, associated with the Etesian winds. Previous studies have indicated the existence of two semi-permanent circulations. One connecting the EM with the Asian monsoon and second, resembles the Hadley Cell, extends across eastern North Africa. Both of them induce descending motion over the EM. The temperature regime in this region is characterized by small inter-diurnal variations, presumably due to a balance that exists between the two governing factors.

However, extreme temperatures, especially heat waves, are observed. Climatologically, the "hot tail" of the temperature distribution is longer than the cool one and heat waves are longer than cool events.

On top of the two governing circulations, there are periods in which the region is subjected to propagation of mid-latitude disturbances entering from Europe and the Western Mediterranean. Extreme events are analyzed with respect to the above circulations. Cool events were found to have most similar circulations as the frequent days, except for an intensification of the lower- to mid-level westerly cool advection due to a penetration of an upper-level trough from Eastern Europe toward the EM. At the same time, no significant change in the circulations connecting the region with the Asian monsoon and the Hadley cell was noted.

Heat waves were found to differ from the cool and the frequent days in several aspects. During hot events, a disconnection from the Asian Monsoon is observed and significant changes in the circulation patterns. In the lower-levels the westerly flow is considerably reduced, and so is the implied cool advection. Three types of heat waves were identified, differing in their development scenarios. One, entitled 'Subtropic', is a result of a northward shift or an intensification of the subtropical high over the region. Second, is the 'Baroclinic' type, induced by a dynamic ridge that develops ahead of a pronounced trough near Greece. The third, entitled 'Tropic', is associated with an intrusion of tropical air mass from south, accompanied by cumulative middle clouds, which are otherwise rare.

REGIONAL AND GLOBAL SCALE PATTERNS ASSOCIATED WITH RAINFALL ANOMALIES IN ISRAEL

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The study shows linkage between the inter-annual variations in the winter rainfall measured in the northern half of Israel and large scale circulations**.** The analysis was done for the mid-winter months, DJF, in which 2/3 of the annual rainfall is obtained in the study region, covering for 47 years.

The correlation between the inter-annual rainfall and each of the indices representing the well- known large-scale oscillations was calculated. The highest (i = 0.51) was obtained with the East Atlantic/West Russia oscillation. The NAO, which dominates the climatic variations over Europe and the Mediterranean, yielded only R = 0.09. Even a combination of 2 indices yielded correlation that did not exceed 0.54.

In order to search for alternative patterns that better explain the precipitation variability, atmospheric fields from the NCEP/NCAR were used, covering the entire earth, including both troposphere and extending to the stratosphere. The average maps for the extreme dry and wet winters show distinct signatures. In the sea level pressure a cyclone was found over Italy in the driest years and over Cyprus in the wettest years. In the 500-hPa, the Mediterranean main trough appeared between Italy and Greece in the driest winters and over Israel in the wettest. The near-tropopause jet over the Atlantic showed a distinct shift in orientation between the two groups of extreme winters and the stratospheric polar jet was found to be stronger by 20% in wettest years with respect to the driest.

Correlation maps between the rainfall time series and the various fields show correlation centers, with amplitudes exceeding 0.6 over the northern hemisphere and 0.4 over the southern. The prominent feature was found in the upper troposphere, in the form of dipole with one center over northeastern end of the Mediterranean and the opposite one - over Western Europe (see fig.1, below). Six indices, based on significant features found in the correlation maps, were derived: Three for the eastern half of the northern hemisphere, entitled 'regional', and 3 for the entire earth, entitled 'global'. The correlations with the regional indices varied between 0.67-0.68 and with the global indices - between 0.46-0.62. A correlation of 0.76 was found between the rainfall in the study area and a combination of 2 indices; one regional - the 500-hPa temperature - and one global – the 30-hPa zonal wind. These results indicate that the winter rainfall variations over the eastern coast of the Mediterranean reflect variations in the circulations encompassing the entire earth, including both hemispheres.

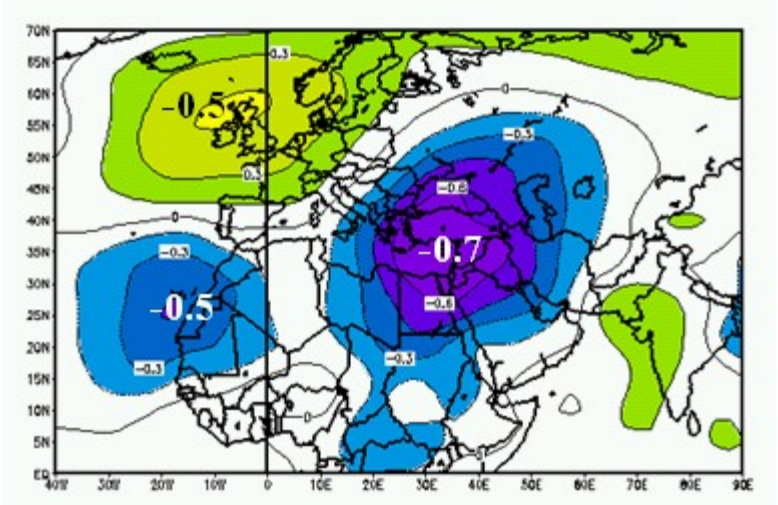

Fig. 1: Correlation between Israel rainfall and 500 hPa gph for DJF

THE ROLE OF EX-HURRICANES ON EXTREME PRECIPITATION EVENTS OVER THE WESTERN MEDITERRANEAN: AN UPDATE BASED ON ERA40 DATA.

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The large-scale meteorological conditions leading to hydrological extreme events over the Western Mediterranean are investigated. Special focus is given to Northwest Italy, a region often affected by such events, and for which an extensive database of hourly rain gauge data is available. In particular, the influence of recurving North Atlantic tropical storms on the development of these events is analysed. The 50 most extreme events from 1958 until 2006 are identified and classified based on hydrological criteria: annual maximum daily rainfall was reached over areas having scales larger than 100 km^2 in the target domain, and intense precipitation occurred for several consecutive days. Based on ERA40 data, the diagnostic analysis of the synoptic developments is performed. Techniques and variables include tracking of the cyclones, moisture advection, backtracing of moisture sources, total precipitable water, large-scale vertical movements and CAPE.

Results exhibit evidence of a significant role of tropical storms in the development of the events. Three basic mechanisms on how tropical storms influence atmospheric flow and moisture transport over the Mediterranean Sea are characterized: In some cases, ex-tropical storms move directly into the Mediterranean Basin and transport moisture into the region. In other cases, recurving tropical depressions influence the formation of trough-ridge systems over the Atlantic or enhance moisture transports across the Atlantic into Southern Europe. The local triggering of the events is in almost all cases associated with cyclogenesis in the Western Mediterranean. The additional moisture advected from the North Atlantic into the Mediterranean Basin, typically 1-3 days before the main precipitation occurs, plays apparently a major role in the magnitude of the events.

INTERANNUAL VARIABILITY OF THE EXCHANGES BETWEEN THE SHELF AND THE OPEN SEA IN THE GULF OF LIONS : SHELF DENSE WATER FORMATION AND CASCADING

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Questions of global change entail elucidation of the mechanisms which control the exchanges at the shelf break. In the Gulf of Lions, one objective is to improve the understanding of processes acting on the shelf (wind driven upwellings, deep water formation, Rhône river plume, continental shelf circulation ...) and their interactions with the along slope shelf current and the bathymetry.

In order to evaluate the climatic evolution and interannual variability of the exchanges, a long term shelf model has been implemented (1/64° horizontal resolution and 130 z vertical levels). A ten years long run has been performed during the period 1990-2000, using a bulk formulation of atmospheric fluxes provided each 6 hours by ECMWF–ERA40 outputs and a basin circulation forcing each 5 days from the MED16-ERA40 outputs (MERCATOR project) through open sea radiative boundary conditions.

The shelf dense water is a particular process acting every winter and driving by the atmospheric conditions (strong dry and cold continental winds). The formation on the shelf and the cascading off the shelf have been studied over ten winters. This analysis focuses on the interannual variability of the dense water mass characteristics and on the interannual variability of the export : volume exported, location, driving factors.

A REGIONAL SYSTEM FOR CLIMATE CHANGE ASSESSMENT IN THE MEDITERRANEAN REGION: PRELIMINARY RESULTS.

The Protheus Group: [1]Artale V., [2]X. Bi, [1]S. Calmanti, [1]A. Carillo, [1]A. Dell'Aquila, [2]F. Giorgi, [2]J. Pal, [1]G. Pisacane, [2]S. Rauscher, [1]P.M. Ruti, [1]G. Sannino, [1]M.V. Struglia

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[2]ICTP, Trieste (Italy)

Climate change assessment and impact studies demand realistic prediction of atmospheric fields, which can be either derived from global-scale simulations through down-scaling procedures, or obtained by running regional climate models which use global-scale fields as boundary conditions. In particular nested limited-area atmospheric models have proven their ability to resolve small features that are missed by large-scale simulations.
At present fully coupled regional climate models are being developed, so that the interactions among the distinct components of the climate system (i.e. ocean, atmosphere, biosphere and sea-ice) are explicitly simulated. Such models are expected to improve our skill in predicting reliable scenarios in complex regions such as the Mediterranean area, which is subject both to the influence of global scale dynamics (e.g. disturbances in the mid-latitudes, strength and meridional extension of the Hadley circulation), and to the effects of local physical processes.
We present a new regional system consisting of the RegCM (atmospheric model), the MITgcm (ocean model) and BATS (Biosphere-Atmosphere Transfer Scheme), coupled via OASIS3.
Preliminary simulations of the coupled system over the Mediterranean area will be discussed.

LINKAGES BETWEEN NORTH ATLANTIC SURFACE WATER CIRCULATION PATTERNS AND MEDITERRANEAN OUTFLOW VARIABILITY ON THE WESTERN IBERIAN MARGIN: EXAMPLES FROM MARINE ISOTOPE STAGES 3 AND 12 TO 10

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The Mediterranean Outflow (MOW) plays a major role in shaping the hydrography and sedimentological patterns within its flow depth (500-1400 m) along the western Iberian margin. Several studies along the southern margin showed that the MOW flowed at greater depths – as deep as 2000 m – during the last glacial maximum (LGM; ca. 21 ka ago). In order to understand the MOW's response to millennial-scale climate variability (Dans-gaard-Oeschger cycles) during the last 50 ka, we performed a multi-proxy study on IMAGES core MD99-2339 from 1200 m water depth in the western Gulf of Cadiz; a site which today is marginally influenced by the lower MOW core. During the glacial interval covered by the sediment sequence (47 to 12 ka ago; MIS 3-2), the grain size and physical property records reveal periodic occurrences of contouritc layers indicating a strengthening of the bottom water current (Voelker et al., 2006; EPSL). Intensification of the deeper MOW core was contemporary with cooling of the surface waters in the Gulf of Cadiz and in the western Mediterranean Sea and with colder temperatures above Greenland, i.e. stadial periods. They, furthermore, coincided with increased Western Mediterranean Deep Water (WMDW) formation in the Gulf of Lions (Sierro et al., 2005; Paleoceanography). The coupling between WMDW formation and deeper MOW flow strength was so tight that even the short-termed cessations of WMDW formation due to Heinrich event related incursions of fresh, subpolar surface waters into the western Mediterranean Sea led to a reduction in MOW flow strength. Incursions of subpolar surface waters, however, were short and also occurred only during parts of the Heinrich events. In general, temperate to subtropical surface waters prevailed in the western Gulf of Cadiz indicating a persistent influence of the Azores current and its paleo-counterpart and thus a strong coupling to the North Atlantic's subtropical gyre circulation.

Further back in time (480 – 330 ka ago) evidence for MOW variability on the mid-depth western Iberian margin is arising from Calypso core MD03-2699 retrieved at 1900 m water depth from the western edge of the Estremadura Spur north of Lisbon. The time interval discussed encompasses the most extreme glacial period of the last 800 ka, MIS 12 (475 – 420 ka, and interglacial MIS 11.31 (408 – 396 ka), which is often seen as a potential "analog" for the current interglacial. Today and during the MIS 11 interglacial period the study site is/ was under the influence of North Atlantic Deep Water (NADW). After 396 ka, however, when continental ice built-up increased and climate started to deteriorate, the benthic stable isotope values at site MD03-2699 begun to diverge from known NADW records. The excursions to lighter benthic ^{18}O values – indicating a warmer and/ or less saline water mass – were accompanied by grain size maxima (increased bottom current strength) and often also coincided with cold spells in the surface waters. As this scenario is so similar to the pattern observed in the Gulf of Cadiz during MIS 3, the benthic isotope and grain size records are interpreted as a deepening of MOW to water depths similar to the LGM and thus an increased MOW influence at the study site. Grain size maxima also occurred during the glacial maxima of MIS 12 and 10, but the isotope evidence is not so conclusive. Terminations 5 and 4 – the transitions from MIS 12 to 11 and 10 to 9, respectively – are, on the other hand, marked by ^{18}O minima that could be linked to a warmer (MOW?) intermediate depth water mass. Trace element analyses on benthic foraminifera shells are currently done to reconstruct bottom water temperatures that should help in the future to distinguish between MOW and NADW/ LSW related signals.

REGIONAL DYNAMICAL DOWNSCALING OF MEDITERRANEAN CLIMATE – CLIMATE CHANGE PERSPECTIVES.

Heiko Paeth

Institute of Geography, University of Wuerzburg, Germany

The Mediterranean Basin is highly diverse due to a fine-scale land-sea distribution and enhanced orographic variance. Climate features like weather extremes, seasonality and ocean circulation arise from a complex interaction between large-scale circulation patterns and regional wind systems. Global climate models are unable to account for these interactions and may, hence, misjudge the regional climate sensitivity in the Mediterranean region to global warming scenarios. One way out of the dilemma may be regional downscaling with high-resolution dynamical models.

Results from the hydrostatic regional climate model REMO are presented. The model is nested in ensemble simulations from the coupled global climate model ECHAM5/MPI-OM which participates in the most recent model initiative of the IPCC 4th Assessment Report. The ensemble integrations with REMO are forced with different IPCC scenarios of greenhouse-gas emissions and newly developed scenarios of land cover changes over North Africa. Changes in climate mean and extreme patterns are analysed, using specific extreme value distributions and a Monte Carlo approach to estimate the significance of extreme value changes.

It is found that the Mediterranean climate is drying and warming until the year 2050. The increase of heat stress is partly twice as much as the mean warming. Changes in heavy rainfall are also projected but less homogeneous in space and partly not significant due to the large amount of uncertainty in the estimate of rainfall extremes.

ASSESSING MECHANISMS OF FUTURE CLIMATE TRENDS OVER THE E. MEDITERRANEAN REGION BASED ON RESULTS OF MULTIPLE RCM SIMULATIONS.

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Results of regional climate modeling (RCM) are characterized by a level of uncertainty due to non-linear and stochastic aspects of the climate system and anthropogenic forcings. Results of a series of RCM experiments on simulation of the present and future climates of the eastern Mediterranean region (EM) with RegCM3 model are analyzed with the aim of determination of an optimal model configuration for RCM studies over the region. The model configuration selected is adopted for simulation of future climate change over the EM. Relative contribution of several major mechanisms in controlling the projected climate change processes over the region is evaluated. Special attention is paid to determination of the role of projected trends of East Atlantic/Western Russia anomaly pattern. Relative importance of the uncertainty arising from insufficient reliability of the climate descriptions by the AOGCMs as well as that of long-distance climate change effects is also evaluated.

Climate change effects on coastal resources and marine environment of Egypt.

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The observed warming of the earth's atmospheric, caused by the "greenhouse effect" is primarily due to a significant increase in anthropogenic emissionsof greenhouse gases, including carbon dioxide, chloroflourocarbons (CFCs), sulfur dioxide, and nitrous oxides. While it as proven impossible to foresee all the possible consequences of a climatic change produce by the rise in greenhouse gas emissions, most scientists anticipate serious environmental and serial impacts in many parts of the world. Predicted environmental changes include a general rise of sea-levels, expansion of dry areas, loss of biological diversity, and increased frequency of extreme weather conditions, including heavy rainfalls, flooding, and storms. Such a climatic disaster may also have enormous social and economic impacts, as altered weather conditions cause failed harvests and contribute to widespread hunger and a dramatic increase in the number of environmental refugees.

Egypt has already assumed a leadership role on climate change in the developing world, although much remains to be done. As one of the first countries to sign and ratify both the Vienna Convention and the 1987 Montreal Protocol, Egypt formally ratified the UN Framework Convention on climate Change (UNFCC) on December 5, 1994. Egypt is also a signatory of the recent Kyoto Protocol and continues to engage in climate change discussions at the highest levels.

This lecture aims to describe how climate change is important for Egypt and what are the Egyptian achievements have been done in this field. Examples are provided outlining how remote sensing can benefit in determining the impact of climate change on the management of the coastal resources and activities in Egypt. Two case studies will describe: one on the Mediterranean Sea (Nile delta subsidence/SLR) and the other on the Red Sea (coral reef bleaching). Recommendations will be made for the future collaboration and use of remote sensing technology in producing the climate change scenarios in Egypt as well as in North African Countries.

The proposed future collaboration derived from the lecture will lead to:

- Bring together decision makers from across a range of stakeholders to discuss the impact of climate change on Egypt
- Discuss status of the international climate change negotiations and implications for Egypt.
- Share information on the science of climate change, the research already underway in Egypt on climate change and continued research needs.
- Proposing climate change projects in Egypt, including the Egypt country Study, the national Action Plan, the National committee for Climate Change in Egypt.

IMPACT OF CLIMATE CHANGE ON WATER RESOURCES IN EGYPT

Dr. Noha Donia

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The Third Assessment Report of the IPCC states that the global average temperature is likely to rise above the 1990 level in a range between 1.4 and 5.8°C by 2100. Some of this warming has already been experienced, although the associated impacts remain difficult to identify with certainty given the confounding factors of natural climate variability and social change. In fact, the longer-term impacts of climate change will include shifting supply and access to key resources such as water. North Africa and the South eastern Mediterranean appear to be highly vulnerable to climate change, but there are insufficient national or regional studies to reach precise conclusion.

The impacts of climate change on water resources supply, availability, and demand will have direct and indirect effect on a wide range of institutional, economic and social factors. The ability of society to adapt and the nature of these effects are not well understood because of the complicated and unpredictable nature of water resources. Besides, the impacts are non-linear, and water resources will be under additional stress due to population growth and competition for financial resources from other sectors, disputes, and water allocation priorities. Besides, present water systems are optimally designed to cope with current climatic conditions and therefore are sensitive to any changes in those conditions. In addition, the changes in the operating rules need to be closely and precisely examined to see if they can reduce the risks of being associated with a system of a fixed infrastructure and designs.

Egypt's vulnerability to climate change is acute. Rapid increases in population and urbanization will aggravate this vulnerability, given the strong linkages of the Nile River, Nile Delta, Coastal resources, and surrounding deserts. This paper reviews the most relevant climate change studies in Egypt that highlights some impacts and adaptation options to the water resources.

SYNOPTIC PATTERNS LEADING TO EXTREME TEMPERATURES OVER PORTUGAL.

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In order to study changes in temperature extremes in Portugal, daily maximum and minimum temperatures from 18 climatological weather stations covering the country were analysed for the period comprised between 1941 and 2006. The daily indices used in this study correspond to the ones indicated by the CLIVAR expert team on climate change detection. Here we have used indices corresponding to the 90th and 10th percentile for both Tmax and Tmin. Furthermore we have computed heatwave and cold spell duration indices with results being aggregated on an annual and seasonal basis. Trends were computed for the entire period (1941-2006) as well as for two consecutive 31-yr periods (1945-1975 and 1976-2006). The most striking results are related with the last period (1976-2006) that reveal a significant increase of heat extreme events for both spring and summer seasons, and a decrease of cold extremes in winter.

Large-scale climatic and dynamical meteorological fields were retrieved from the NCAR/NCEP Reanalyses data sets for the 1958–2006 period and composites were then obtained for heatwave days, i.e. when summer Tmax values are above the 90th percentile (for the 1961-1990 reference period). Additionally we have also computed cold spell days, i.e. when winter Tmin values are below 10th percentile (for the 1961-1990 reference period). Anomaly fields of climate variables (850 hPa temperature and Tmax and Tmin) are interpreted based on physical mechanisms associated with dynamical variables such as SLP, the surface wind field or the 500 hPa geopotential height.

Finally, in order to access the impact of major teleconnection patterns on Portuguese temperature extremes, we computed seasonal correlations between major Northern Hemisphere teleconnection patterns (NAO, AO, EA and SCAN) and heatwaves and cold spell days.

CLIMATE IMPACTS OVER THE MEDITERRANEAN BASIN ASSOCIATED WITH BLOCKING OCCURRENCE

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A recently developed blocking climatology has been applied to characterize the climatic impacts over the Mediterranean basin associated with the occurrence of blocking episodes over the Atlantic (ATL) [90ºW, 0º] and European (EU) [0º, 90ºE] sectors at seasonal scales. Composites of several climatic variables (including 500 hPa geopotential height, temperature of the lower troposphere, precipitation and frequency of cyclones) are analysed for blocked and non-blocked situations. A two-tailed t-test is used to compare and to assess the spatial extent of all significant differences.

The seasonal-dependent impacts are described for both ATL and EUR sectors. In addition, anomaly fields of surface or low troposphere climate variables are interpreted on the basis of large-scale physical mechanisms, such as the anomalous mean flow (characterised by the 500 hPa geopotential height and the surface wind) and the anomalous eddy activity (characterised by the frequency of cyclones).

ATMOSPHERIC CONDITIONS IN THE EASTERN MEDITERRANEAN DURING EXTREME SUMMER EVENTS - PRELIMINARY RESULTS

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The summer temperature regime in the Eastern Mediterranean is characterized by high stability and small inter-diurnal variations. Even though, there are periods of heat waves, several days long, when the temperature exceeds the seasonal average by several standard deviations. Cool spells occur as well, though are shorter than the heat waves and are less extreme.

A 3-D analysis, using composite air-trajectories, vertical profiles and isobaric maps for the 5% quantile of the lower, median and higher temperature, was performed. All of them show distinct differences between the 3 types of days, the 'hot', 'regular' and 'cool' days. The temperature differences were found only at the lower levels, up to 4 km. As for the wind, the lower to mid-level westerly flow, implying a cool advection, was found as the major discriminator between the 3 types of days, being strongest during the cool days and weakest during the hot days, as is demonstrated in Fig. 1. The vertical velocity differed only at the mid and upper levels and, unexpectedly, the upper-level subsidence was found maximal in the cool days and minimal in the hot days. The latter contradicts the common idea according which subsidence is the cause for the heat waves over the Eastern Mediterranean.

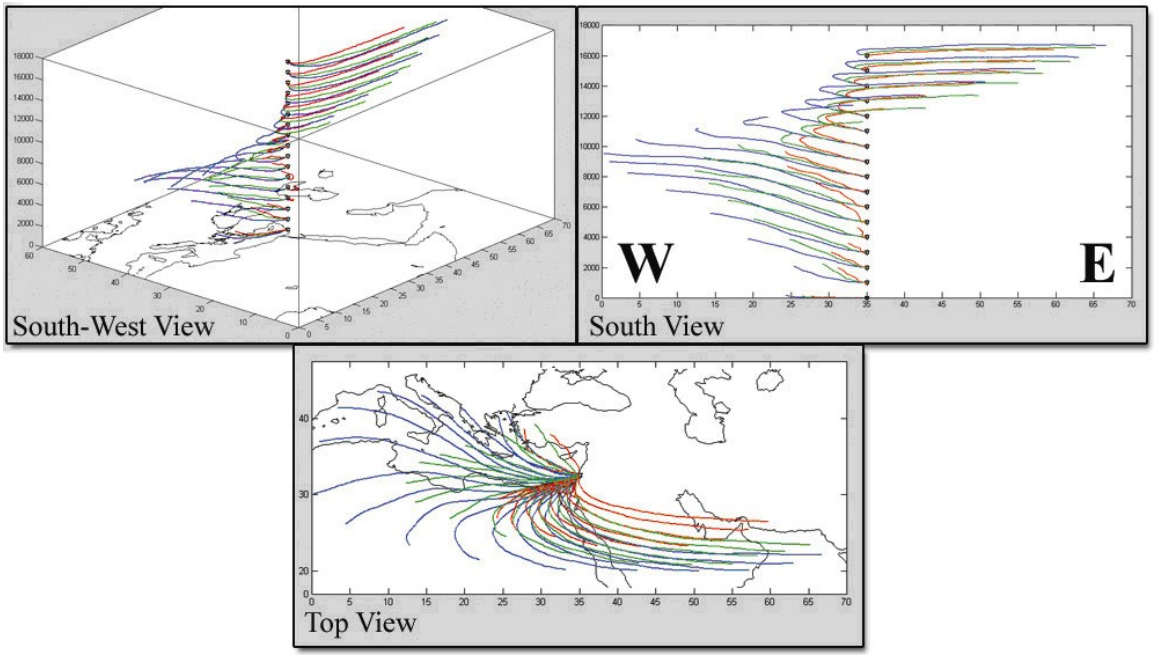

Fig. 1: Seventy-two hours air back-trajectories (using HYSPLIT model), ending in Israel, in 1 km vertical separation, viewed from 3 angles. The blue, green and red lines represent the cool, regular (median) and hot days, respectively.

TRENDS AND ANOMALIES OF THE REGIONAL PRECIPITATION IN SPAIN ALONG THE 20TH CENTURY.

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The present contribution sets out to describe the evolution of monthly precipitation in Spain for the period 1897-1998 from a regional point of view, taking into account the impact of the selected period and number of stations. A comparison with the results obtained from previous works is also made. The study focuses on analysing precipitation anomalies, endeavouring to address the possible existence of any trends, as well as evaluating the influence of the NAO on rainfall evolution. Three periods of study were used in analysing these topics: i) 1940–1996, the period selected for undertaking the regionalisation from more than 5,000 stations, and applied for the analysis of water resources in Spain, ii) 1897–1998, the period selected for obtaining long areal rainfall series in each region from 106 stations, and 1897–1940, the period selected for analysing the non-stationarity of the precipitation features. All series were submitted to a process of gap-filling by the multiple correlation method (CORMUL). Average values of precipitation depends strongly of the sample of stations selected, meanwhile they are similar for the three periods considered. The main results obtained for the period 1897–1998 show the existence of two major common dry periods: 1898–1911 and the early part of the year for 1989–1998. Only one common wet period exists, in the second half of the year for the 1989–1998 period. No major trends or seasonal displacements exist. Taking into account the period 1897–1998 spring shows a negative trend of 0.51 mm/yr for the SC region, and the BAL region have a negative trend of 0.28 mm/yr for summer. The largest positive annual trend can be observed in the NW region with a value of +1.50 mm/yr. When the period 1897–1940 is considered, the situation changes completely and a positive trend above +5 mm/yr is found in the NW, N and NE regions, probably forced by the negative anomaly of the first years of the series. However, for the period 1940–1996, any trend is found. Concerning the relationship between regional precipitation and NAO, the results show that there is an appreciable correlation for the Southern Centre region. The correlations between the NAOI and monthly areal precipitation figures are lower than 0.7 in absolute value, and negative for all regions, for the period 1897-1998. When seasonal values are considered, a good correlation of 0.7 is found for winter in the SC region, and values below 0.5 in the NE, E and NC regions. The correlation NAOI-precipitation increases when the period 1940-1996 is considered, arriving until 0.8 for the winter season in the SC region.

INFLUENCE OF TELECONNECTION PATTERNS ON THE MEDITERRANEAN MARINE WAVE HEIGHT DISTRIBUTION

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This contribution considers the SWH (Significant Wave Height) distribution in the Mediterranean Sea during the second half of the 20th century, which is computed on the basis of the WAM (WAve Model) simulations. The forcing wind fields are provided by the ERA-40 reanalysis and the HIPOCAS project and cover the period 1958-2001. Simulations shows a large interannual and interseasonal variability, with a shift of most energetic regimes from western (in winter) to eastern (in summer) areas and a variability more strongly linked to mid-latitude patterns in the western areas. Results of the two simulations are compared and used for identifying the effect of mid-latitude teleconnection patterns (such as NAO, EAWR, SCAN, etc.) on the SWH distribution inside the Mediterranean basin.

ATLANTIC INFLUENCE ON WESTERN MEDITERRANEAN MESOSCALE CONVECTIVE SYSTEMS

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The Mediterranean region is characterized by frequent events of torrential rainfalls. Heavy rain events are specially intense over the Western part of Mediterranean area (WM). Special interest is focused on understanding Mesoscale Convective Systems (MCSs) occurred in Mediterranean basin due to the important damages which usually enclosed these episodes. The aim of this work is to evaluate the impact of Atlantic general circulation on the MCSs development, affecting westernmost Mediterranean Sea and Iberian Peninsula. A total of 12 cases occurring between 1982 and 2002 are studied.

In order to identify the main Atlantic circulation patterns involved in Iberian heavy rainfall episodes, a method for WM MCSs classification based on both dynamical and thermodynamical instability components is proposed. The dynamical perspective approaches the synoptic/mesoscalar features at different atmospheric levels involved in MCSs episodes as the thermodynamic attributes provide local disturbances. Preliminary results show that most of the cases were mainly associated to either blocking episodes or cut-off lows over Europe. WM MCSs occurred during cut-off lows or intense troughs detected at 500hPa level were classified as type A. Those MCSs developed under the influence of the trough portion of a blocking episode are considered as type B. Moisture sources evolution of type A and B Atlantic-influenced MCSs are estimated with a lagrangian particle simulation model providing a detailed description of the air masses origin and behaviour involved in each heavy rain episode. 3-hour specific humidity is assessed along 72-hour backward trajectories of simulated air particles.

Type A MCSs are dynamically characterized by presenting a high Potential Vorticity (PV) anomaly at 330 K isentropic surface. These MCSs also present a strong Q vector convergence. Thermodynamical conditions were evaluated with Convective Available Potential Energy (CAPE), Lifted Index, Total Totals, K-index and Sweat. Backward trajectories associated with most of the type A MCSs show that WM was the main humidity source.

Dynamical features of type B MCSs hardly enhance the instability processes involved. Weak PV anomalies are presented. Analogue behaviour is found in thermodynamical indices. There is not found a common pattern for the humidity sources available for type B MCSs.

SUMMER-FALL TROPICAL PRECIPITATION RELATED TO MEDITERRANEAN SST ANOMALIES

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This work presents a description of atmospheric response in relation to the third coupled mode between the summer atlantic-mediterranean sea surface temperature (sst) anomaly and north atlantic anomalous rainfall based on observational data. To this aim, the authors analyse the impact of the sst anomalies applying a statistical tool of lagged extended maximum covariance analysis (emca; polo et al. 2007, garcía-serrano et al. 2007). In particular, the 4-months jjas sequence is chosen to study the influence of the summer sst in relation to atlantic basin precipitation (pcp). Different 4-months pcp sequences, centred in jjas, and lagging one month forward (jjas to djfm) are computed. The study is focused on the 1979/80-2001/02 time period. Monthly cmap precipitation and noaa extended reconstructed sst dataset have been used to perform the sst-pcp emca. The observed atmospheric response associated with the emca modes has been studied using the ewra-40 reanalysis data.

The first mode, which accounts for more than 40% of the squared covariance fraction (scf), involves sst anomalies related to the equatorial mode or atlantic niño; the second one, which accounts for 15% of the scf, is associated with the summer horseshoe pattern and the winter nao (or sst-tripole); whilst, the *third emca mode* (scf = 10%) is connected with mediterranean sea sst anomalies and a meridional sst-gradient in the north atlantic midlatitudes (fig. 1a).

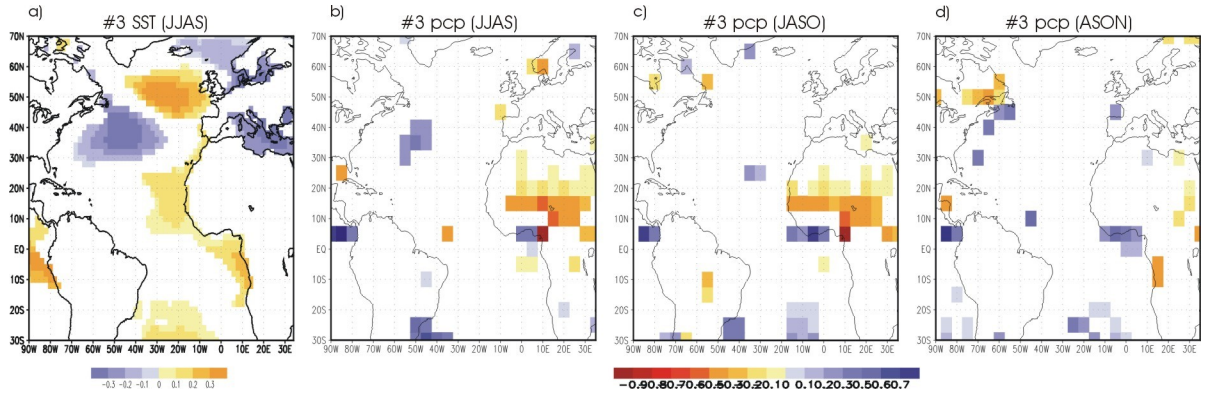

Figure 1. Third EMCA mode between summer Tropical Atlantic-Mediterranean SST anomalies and the Atlantic precipitation from summer to winter

This #3 SST-EMCA pattern is associated with a rainfall dipole in the West African Monsoon (WAM) area, involving negative/positive anomalies precipitation over Sahel/Guinean Coast during JJAS and JASO (Fig. 1b-c). In the following lagged season, ASON, the anomalous PCP only reveals a weak negative rainfall remaining over the Gulf of Guinea (Fig. 1d). The 200hPa streamfunction anomaly points out an extended anticyclonic circulation with two closed lobes (Scandinavian Peninsula and central North Atlantic) during JJAS and a persistent one displaced toward eastern Atlantic basin in JASO-ASON, involving upper easterly flow in African subtropical latitudes which weakens the Tropical Easterly Jet and convection over Sudan-Sahel region.

The #3 SST-EMCA regressed onto the previous late winter season presents a persistence of the Mediterranean SST anomalies from FMAM, while the SST anomalies over the Northwestern Atlantic start at boreal spring-summer (AMJJ-MJJA). This feature implies a more active role of the Mediterranean SST into the WAM variability, as it has shown by Polo et al. (2007).

WEATHER REGIMES AND LOCAL CLIMATE ON THE MEDITERRANEAN BASIN

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Large-scale atmospheric circulation is frequently described in terms of a few of preferred and recurrent patterns in the atmospheric state space, the so-called weather regimes. They are commonly identified through clustering analysis, that determines a few number of atmospheric patterns spatially well-defined. The low frequency atmospheric variability over the Mediterranean region is described through the weather regimes, obtained by using a clustering algorithm applied on the geopotential height at 500 hPa.

In this work, we show that the weather regimes are associated with significant local temperature and precipitation anomalies in Europe. Moreover, links between the Mediterranean weather regimes and climate extremes of precipitation over Europe are examined. As part of the objectives of the French project CYPRIM, we focus on the French Cevennes region, often the theater of dramatic flash flood episodes happening during the autumn season. The excitation of two mediterranean weather regimes is associated to the occurrence of extreme precipitation episodes over the Cevennes.

In the second part of this work, we study whether the Mediterranean weather regimes can be related to the phases of some intra-seasonal atmospheric oscillation. By using the Multi Channel Singular Spectrum Analysis (MSSA), we identify a 50-day oscillation over the Mediterranean region. The phases of this oscillation are found to be consistent with the preferred weather regimes transitions. This could influence intra-seasonal predictability and suggests that links between the episodic (weather regimes) and oscillatory (intra-seasonal oscillations) approaches may also apply to the regional scale.

MEDITERRANEAN CLIMATE CHANGES IN GLACIAL TIMES AND THEIR LINKS WITH GLOBAL CHANGE: A MODEL STUDY.

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During the last glacial period, climatic reconstructions show that the Mediterranean climate underwent large fluctuations. These fluctuations appear to be concommittent with global/hemispheric scale climatic events such as the Heinrich events, during which huge iceberg discharges from the North American ice-sheet occured in the mid-latitude North Atlantic. The Atlantic Meridional Overturning Circulation appear to strongly decrease during these events. This is believed to be one of the mechanisms through which an event over the North Atlantic has global impacts. In addition to this, the sea surface temperature changes have an impact on the atmospheric circulation, which could be another factor in the global response to Heinrich events. In this work, we will examine the response of the Mediterranean climate in different glacial climate simulations characterised by different Atlantic Meridional Overturning rates.

CIRCULATION REGIMES AND SEA SURFACE TEMPERATURES IN THE NORTH ATLANTIC

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Two experiments are run to assess the dependence of weather regimes on the SST anomalies pattern in a preindustrial control climate and vice-versa. A first experiment consists of a global coupled simulation involving an atmosphere model ARPEGE-Climat 4 and a mixed layer model. The coupling time step is 3h. The restoring term below the thermocline and the flux correction are computed from the IPCC-AR4 preindustrial control simulation conducted with CNRM-CM3. The second experiment consists in forcing ARPEGE-Climat 4 with 3-hourly ocean surface data from the fully coupled experiment. This approach allows to disentangle the impact of the atmosphere on the sea surface from the forcing of the atmosphere by sea surface temperature anomalies. The interest of these experiments stems from the high vertical resolution of the ocean model (91 levels). This high resolution allows to improve the representation of diurnal cycle of the mixed layer and the heat budget in the upper ocean. All models are run on a common stretched grid centred on western Europe with a maximum resolution of 30km. The analysis of the coupling between weather regimes and sea surface temperature anomalies focuses on the North Atlantic.

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